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ABSTRACT

Paper and pencil tests rarely assess children's developing mathematical and scientific concepts validly. There are, however, a number of authentic and meaningful ways to assess these processes. Anecdotal notes--recorded observations of children that concern what they say and do--reveal a considerable amount about these developing concepts. Drawings, paintings, constructions, and dramatizations illustrate in creative ways what a child knows. Children's journal writing, field note reports, and demonstrations are also thoughtful approaches to embedding assessment in the curriculum. This paper presents the experiences of graduate students in a masters degree program in early childhood education with assessing children's learning using a combination of those strategies: anecdotal notes, drawings, paintings, constructions, and dramatizations; and children's journal writing, field note reports, and demonstrations. (ASK)

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Authentic Assessment of Young Children's Developing Concepts in Mathematics and Science

Paper prepared for presentation at the Seventh Australia and New Zealand Conference on the First Years of School, Canberra, January 1998 by

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In the United States in recent years there has been a call for national standardised tests to assess children's capabilities, with particular reference to science and mathematics learning. Internationally also, there has been comparison among countries of children's mathematics and science learning through the standardised measures associated with the International Association for the Evaluation of Educational Achievement studies. Ironically, this comes at a time when we as teacher educators are advocating the development of more meaningful science and mathematics standards and curricula, and certainly more meaningful and authentic ways of assessing what children know and can do in these areas. In curriculum development, relatively new science and mathematics standards(National Council for Teachers of Mathematics, 1989; National Centre for Improving Science Education 1990; American Association for Improving Science, 1989, 1993) have been developed. These focus on curiosity and exploration, and foster children's scientific and mathematical questioning skills, their ability to organise information and their ability to experiment systematically to generate results. The emphasis for children lies in active participation, investigation, reflection and small group exploration of concepts, rather than a concentration on rote memory and teacher demonstration of limited content. In turn, the emphasis on assessment practice has shifted from written tests of content to the assessment of children's knowledge and skills in a variety of ways. These focus on gaining information concerning learning processes and learning styles, in addition to assessing information and/or skills mastered.

Paper and pencil tests rarely assess children's developing mathematical and scientific concepts validly. There are however, a number of authentic and meaningful ways to assess these processes. "*Multiple assessment windows ensure a richer, more balanced picture of a child*" (McAfee and Leong, 1994, p.77). Anecdotal notes - recorded observations of children, what they say and do - reveal a considerable amount about these developing concepts. Drawings, paintings, constructions and dramatisations illustrate in creative ways what the child knows.

Children's journal writing, field notes reports and demonstrations are also thoughtful approaches to "embedding" assessment in the curriculum. Monitoring children engaged in mathematics and science tasks provides information about aspects of the process that the child fully understands and aspects which remain unclear or confused and which need more practise or further teaching.

In June and July of 1997, we worked in a teacher education summer school programme for a masters degree in early childhood education at Oakland University in Michigan. The students were practising teachers, mostly teaching in the elementary grades (K-3). This summer school programme was combined with a mathematics and science holiday programme for young children, aged from two to nine years, which provided the graduate students with first-hand opportunities to experiment with a developmental, child- centred approach to learning and teaching and also to experiment with the assessment of this learning in meaningful ways.

The graduate students' two classes in curriculum development and assessment ran concurrently for a period of two weeks prior to the children's camp.
This time tabling enabled us to help the students not only to develop the skills, knowledge and attitudes necessary to work with the children using a developmental child-centred approach but also to develop the skills to assess their learning in authentic and meaningful ways. We asked the graduate students to assess the children's learning using a combination of the following strategies:

Anecdotal notes

Anecdotal notes are "*written accounts of significant pupil events and behaviours that the teacher has observed*" (Airasian, 1994, p.250). They are jottings of information concerning what a child does or says which provide some insight into what the child knows, is interested in, can do, or is able to say or describe. Anecdotal notes need

not be lengthy, however, they must describe in detail the learning event and should record factual descriptions without incorporating teachers' judgements or inferences. When collected over a period of time and related to a range of experiences these anecdotal notes are likely to provide information useful to making valid decisions about children's learning.

Anecdotal notes in mathematics for example, might detail a child's attempt at one to one correspondence as he/she places a serviette and a cup on the table for each child at tea time. Anecdotal notes may contain a record of a child's comments while engaged in block play such as "*this is as long as two of these*" and *'this can go above a bridge"*, that reveal language and concept formation relating to number, size and spatial relationships. Recording anecdotal information concerning children's scientific investigations may reveal observational skills for example *" the salamander only comes out on days when the rain makes it dark"* or descriptive expressive language such as *" the tongue must be sticky, it never drops the cricket"*. A child may talk about his/her pattern as he/she places various wooden shapes on the floor, for example "*blue circle, red circle, blue circle, red circle, green triangle"* and says *"I need some more red circles if I'm going to do another one of blue"*.

Although there are a variety of ways to write and organise anecdotal notes, we chose to adapt a method used by Shannan and her colleagues in their work at "High/Scope", an internationally known pre-school centre based in the Detroit area, as we felt that it was an efficient method for busy teachers. This approach involves allocating a 5" x 8" notecard to each child in the group. Cards are headed with the child's name and divided into categories that correspond with the class curriculum. For pre-school children the categories may be language, literacy, physical development, social development, and cognitive development. For children in their second or third year at school the categories would probably be language arts, science, mathematics, social science, the arts, and physical education.

Social Relations	Language/Literacy	Music/Physical
9/2 Called to Evan. "Look, cool house. We have bugs" Showed him block house. Evan asked where are the bugs. 9/4 Parallel play w/ Legos Did not converse w/ others 11/6 "He said I was bad boy" (in tears) Teacher- Why did he say that? Hiroto. Shrug. Teacher walked Hiroto to area & mediated conflict	10/1 Used flannel board pieces to retell Itsy Bitsy Spider - sang in soft voice 10/20 "How do you say Guh?" (Trying to write ghost) Teacher- what letter is that? "I don't know" Teacher- G. Hiroto wrote G. Earlier in day, similar conversation for R sound 11/10 Tears when Mom was ready to leave. Mom & Hiroto conversed in Japanese. Mom seemed to be trying to get Hiroto to say he would be happy.	10/4 Galloped from area to area in classroom 10/21 Clapped to beat. Maintained correct beat w/ changes from medium to slow to fast 10/24 Relaxed pencil grip 10/24 Ran smoothly on playground. Can pump on swings w/ initial push 11/10 "Sing yellow submarine"

Initiative	Creative Representation	Science/Mathematics
10/20 "I want to play with the blocks" 10/31 Cried when Mom left for 3 days. No distress prior to this 11/4 Asked Mom if Hiroto was having difficulties at home. She said he was following her from room to room. 11/6 "I'm a circle. Where I'm going now?" Teacher prompt to look at task board. "Group box"	9/4 Used Legos to make an airplane. Searched in box before choosing each piece. Sometimes tossed pieces back after trying on airplane 9/25 What are you building with the blocks? "A dinosaur playground" Multi-story structure w/ some dinosaurs covered. 10/18 Used big blocks to build "a cage for T-Rex babies". Called teacher to see. Told Tommy "This part is open because they like us to sing." Teacher what do you sing? "Christmas songs." 11/6 Made flag w/ paper & markers. (American flag) After showing classmates he returned to table & made Japanese flag on other side.	10/9 Counted # of cups needed for snack. One to one correspondence o.k. Rote counting to 11 10/13 Descriptive words Characteristic - 3 words Function - 1 word Pencil- yellow, long, pointy, write with it. 11/6 one-to-one counting ok Helped Justin put 2 back so he would have 5 chips 11/10 Following directions: brown chip in yellow box brown chip on line by blue box. (Teacher repeated directions emphasizing by)

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By using a metal ring to hold all the cards together, teachers are able to carry the notes with them as they work with and observe children. Entering the notes in categories enables an overall picture of the child to be built up quickly, and the format provides on-going, up to date information which can be used in further planning, and later summarised to provide an accurate overall picture of the child's progress and attainment.

Several sessions on writing anecdotal notes were included in the masters programme at Oakland. These described the procedure in detail and stressed the need for detailed description of the learning event, the importance of recording exactly what was said or done by the child (while the event was occurring or as soon as possible afterwards), and the need to avoid judgmental terms or summations. The students assessed a large number of sample anecdotal notes provided by Shannan, discarding those that did not meet the criteria and, with much discussion, allocating the remainder to categories. As a follow-up assignment they were required to record at least one hundred anecdotal notes about the children with whom they were working during a two week period. Although this initially presented a formidable task for the students, it proved to be of immense value in developing their confidence in writing the notes and their ability to make decisions regarding which behaviours to record as indicators of meaningful learning. Producing a large number of notes for each individual child enabled them to see how a gradual picture of each child was built up and discouraged the practice of making judgements on limited data. All of the graduate students subsequently achieved this task and were encouraged by and enthusiastic about the experience.

Children's drawings, paintings, constructions and dramatisations.

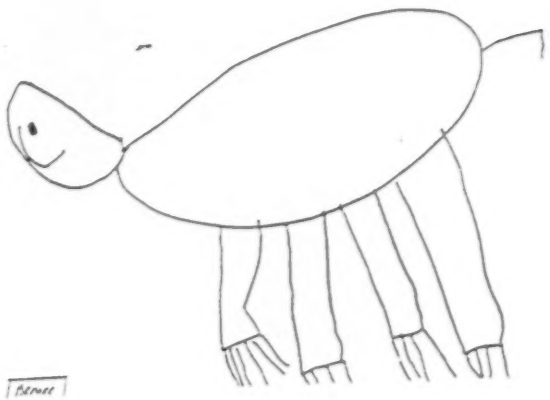
When children are "playing" with developing ideas or concepts, they typically represent them creatively, either by recreating them through art or through pretending. Growing concepts in mathematics and science can be portrayed wonderfully by these means, and usually reveal much more about a child's knowledge than traditional tests. Some examples of creative representations are:

> Children drawing pictures that provide details of an insect's body parts, or drawing an arachnid and an insect and comparing and contrasting the two.
>
> A young child pretending to be an animal and "acting out" characteristics of that animal for classmates to guess what he/she is pretending to be.
>
> A young student, engaged in the study of the life cycles of a familiar species, creating clay figures of eggs, tadpoles at various stages and an adult frog, and displaying them in developmental sequence.
>
> Two children working on a poster describing how to make sugar cookies illustrating each step of the written directions and drawing each of the ingredients to show amounts (two eggs, one and a half cups of milk, etc.).

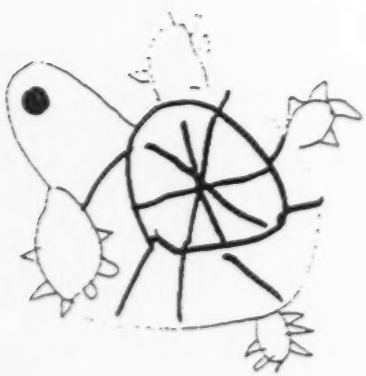
Work samples such as these are examples of 'embedded assessment" - they are learning experiences in themselves, as well as providing a great deal of information concerning what the child knows and thinks.

Children's creative representations can provide illustrations of progression in their knowledge and skills over time. Teachers can provide pre and post-instruction opportunities for children to represent what they know. Finding out what children know before study in a certain area occurs enables the teacher to focus instruction on specific needs. It also provides a basis for the teacher to assess more accurately what children learn as a result of the classroom instruction.

These examples from children in the Oakland summer holiday camp are representations of turtles before a box turtle became a camp pet.



As a result of the children's experiences in observing touching, talking and reading about box turtles, later representations such as these show many more details and a more realistic representation.



Creative representations can also reflect the student's disposition towards science and mathematics learning and reveal their likes, dislikes, attitudes and biases. For example, young campers attending Oakland University's summer science and mathematics day camp draw a scientist on the first day of camp. They typically draw stereotypic, white, eccentric looking (glasses, wild hair) males in laboratories.

When children drew a scientist at the end of camp, they tended to draw themselves studying insects, animals or physical phenomena outdoors with friends.

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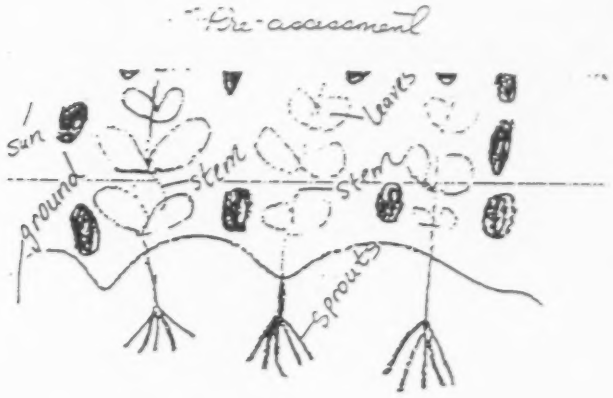
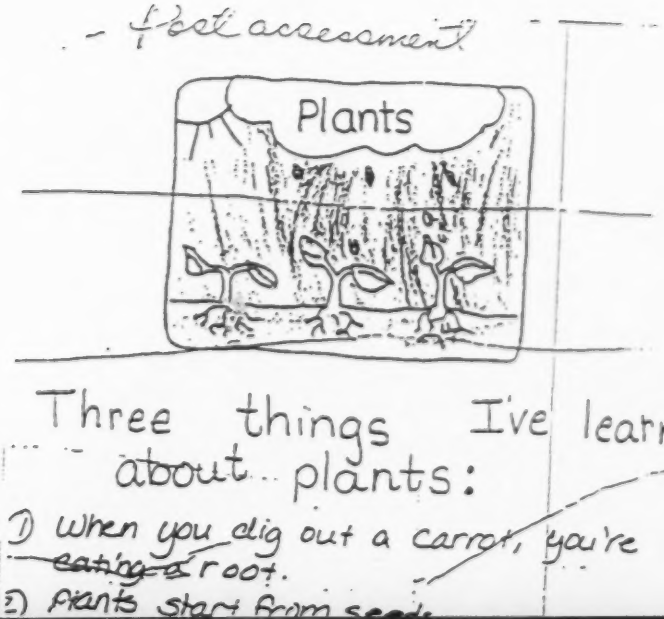
Comparing 'before' and 'after' pictures such as these helps teachers to judge children's movement towards such benchmarks as

> *"everyone can do science and invent things and ideas"* and
> *"in doing science it is often helpful to work in a team and share findings with others".* *(AAAS 1993 Science Benchmarks for K-2)*

Teachers can assess children's growing knowledge as their drawings, paintings, constructions and dramatisations reveal what they know about the characteristics and properties of living things, the processes of life and change, and the identification of relationships and patterns in everyday experiences.




Post assessment
Plants
Three things I've learnec about plants:
1) When you dig out a carrot, you're eating a root.
2) Plants start from seed

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Science and Mathematics Journals.

Science and mathematics journals can provide children with regular experiences of recording information in writing. Children's journal entries provide authentic evidence for the teacher of the children's writing skills, the organisation of their thinking about certain concepts and their growth over time. They also provide information related to particular individual interests and help to identify areas of strength, weakness and confusion. They give the children written records of their own growth in the skills of observation and recording of these observations. Furthermore, they remind children of key ideas and allow them to examine patterns in their observations, to reflect upon their strategies for learning and to consider the steps they may take in solving further problems.

Children's journals can have different forms, for example they may involve simple note making, or they could provide a review of the events of the day or a specific period of time during the day. Their writing may centre on a unit of instruction, or it may be concerned with aspects of particular interest to the child. One of the important features of journal writing is that it provides a basis for communication between the child and the teacher. Through this medium, the child can ask questions or seek assistance as well as recording areas of success or interest.

Children's journals are likely to provide the most valid reflections of their learning in relation to many specific curriculum benchmarks. For science benchmarks which require the child to notice and understand processes, for example

> *"people can often learn about things around them by just observing those things carefully, but sometimes they can learn more by doing something to things and seeing what happens"* and
>
> *"describing things as accurately as possible is important in science because it enables people to compare their observations with others". (AAAS 1993 Science Benchmarks for K-2)*

journal entries which record the problem and analyse the process would provide an appropriate, authentic measure of the child's understanding.

The graduate students used journal writing in a variety of ways when working with children at Oakland. For example one group encouraged the children to use journal entries to plan their activities for the following day; children in another groups were required to make a daily entry recording the day's highlights for them. These formed the basis of subsequent child-generated newsletters to parents. Younger children were able to participate in journal writing activities by dictating their thoughts/views to an adult and were encouraged to illustrate these. The journal entries provided an authentic record of children's attitudes and understandings in relation to their camp experiences, and helped the students to make informed decisions regarding planning for further learning.

By the end of their course at Oakland, the graduate students had gained considerable information about the abilities, understandings and interests of the children involved in the science and mathematics summer holiday camp. An emphasis on a child-centred approach towards their teaching required the students to consider the children as individuals, and to take into account and plan for their individual needs. The programmes planned and implemented by the students resulted in the children's engagement in a wide range of experiences which provided opportunities for them to show their capabilities in a variety of ways. The graduate students were thus increasingly able to gather and use the information embedded in the daily activities to assess the learning taking place. The growing awareness that assessment tasks which were isolated from the teaching learning situation were neither necessary, nor likely to provide them with meaningful information about children's learning, was a valuable learning experience for them.

Examining what children do, what they produce and how they do it in the natural course of the classroom events is essential for teachers' understandings of how the children are doing and how the programme is serving them. This approach to assessment .....appraises what children typically do without altering the curriculum for assessment's sake (Bredecamp and Rosegrant, 1992, p.53).

By taking this approach, assessment is truly embedded into the classroom programme and does not stand in isolation to it.

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